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(54) Abstract Title: Downhole deployment valve with sensors

(57) A downhole deployment valve 110 isolates an upper section 130 of wellbore so that a tool string 500 can be assembled therein before being deployed into a lower section 120. Sensors 128, 129 monitor wellbore conditions in each section. Preferably, they measure pressure and allow pressure in the upper section to be equalised with that in the lower section before the valve member 230 (typically a flapper valve) is re-opened. Also disclosed is a telemetry system (figure 7) in which a downhole tool (702) transmits electromagnetic signals (704) to an instrument sub (706) associated with the deployment valve. The signals are received by the sub and relayed to a surface control unit via a wireline.

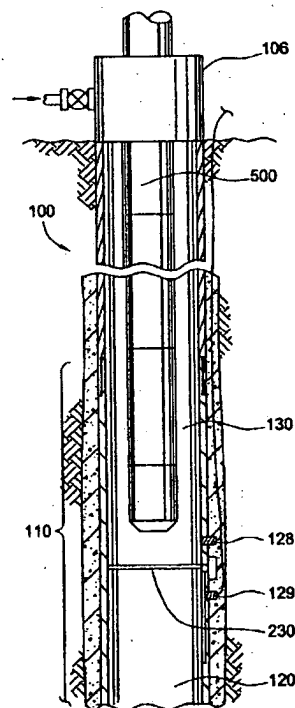


FIG. 5

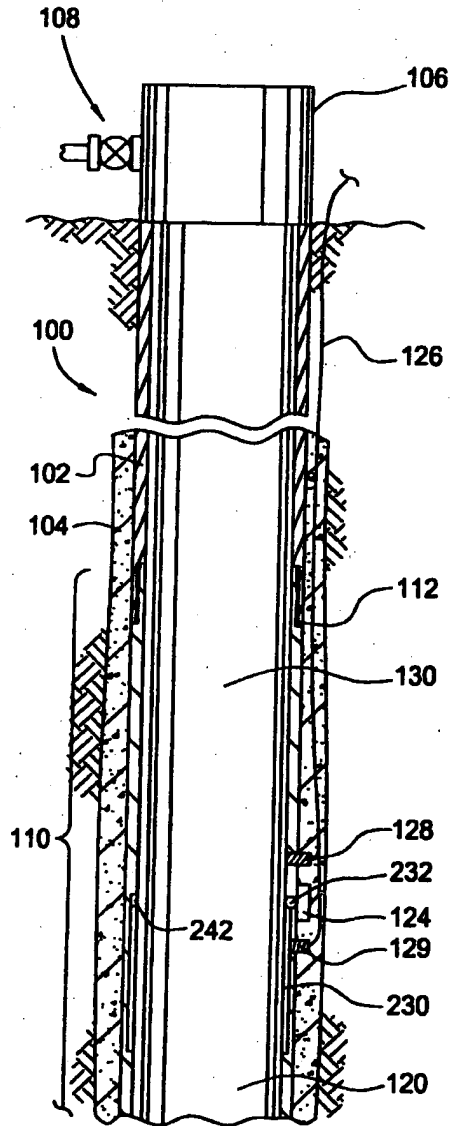


FIG. 1

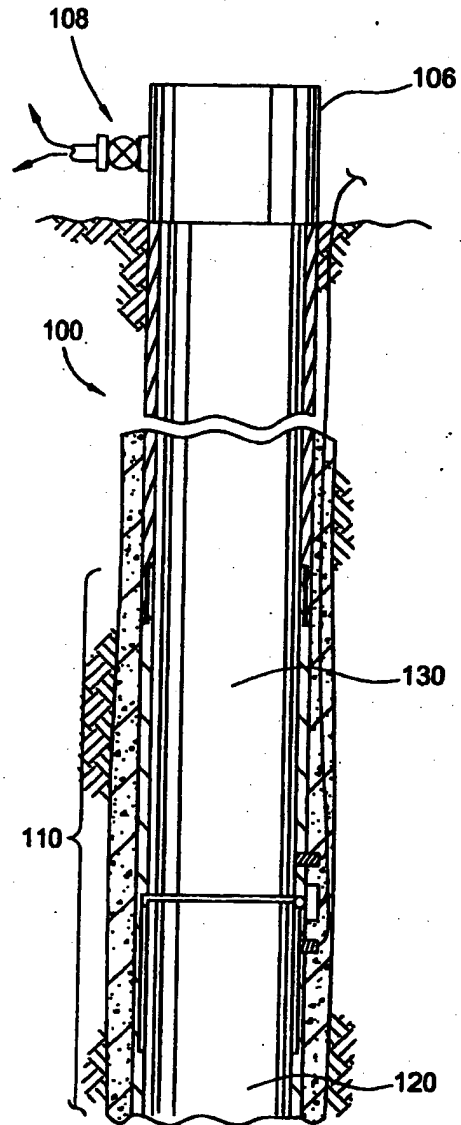


FIG. 4

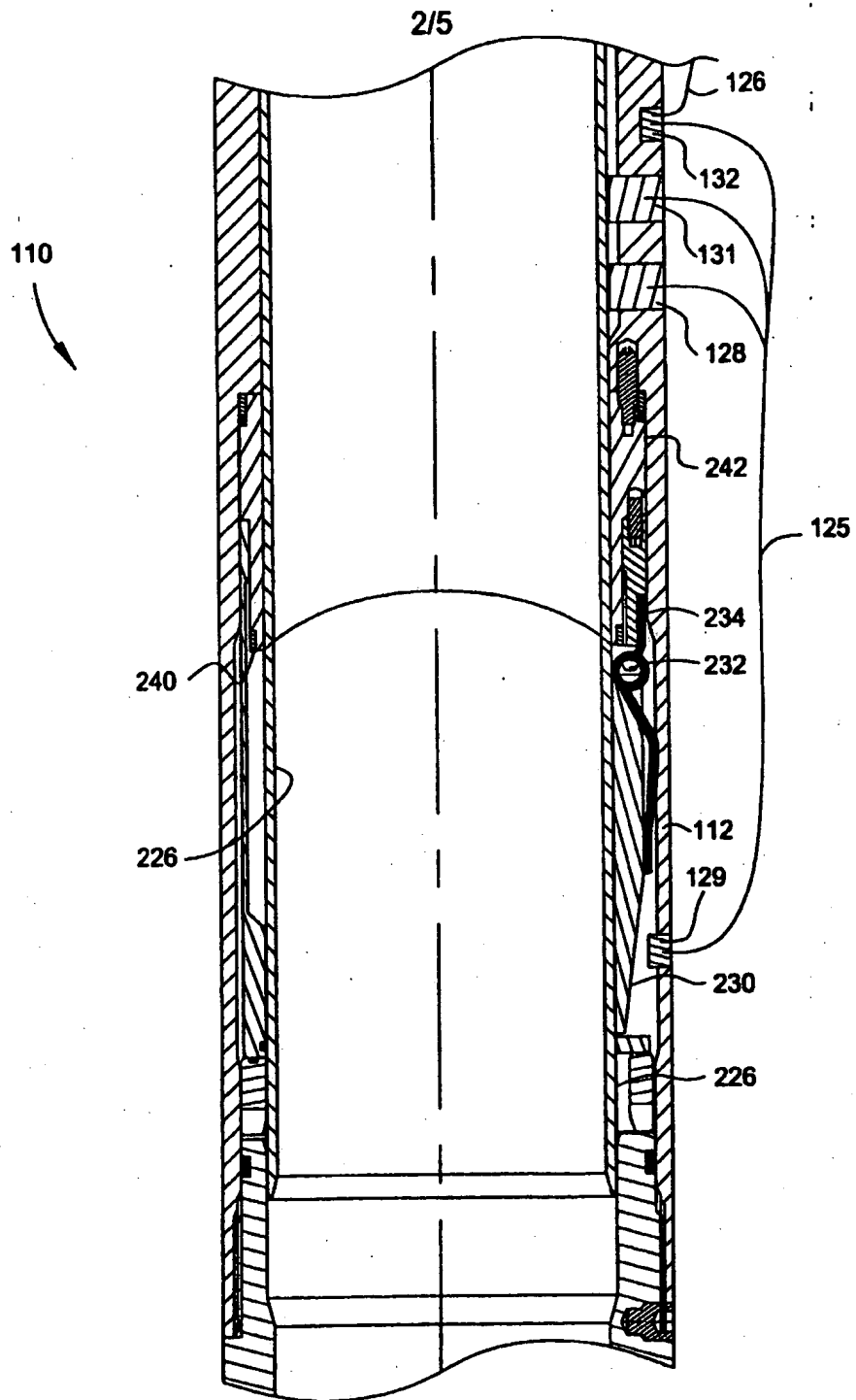


FIG. 2

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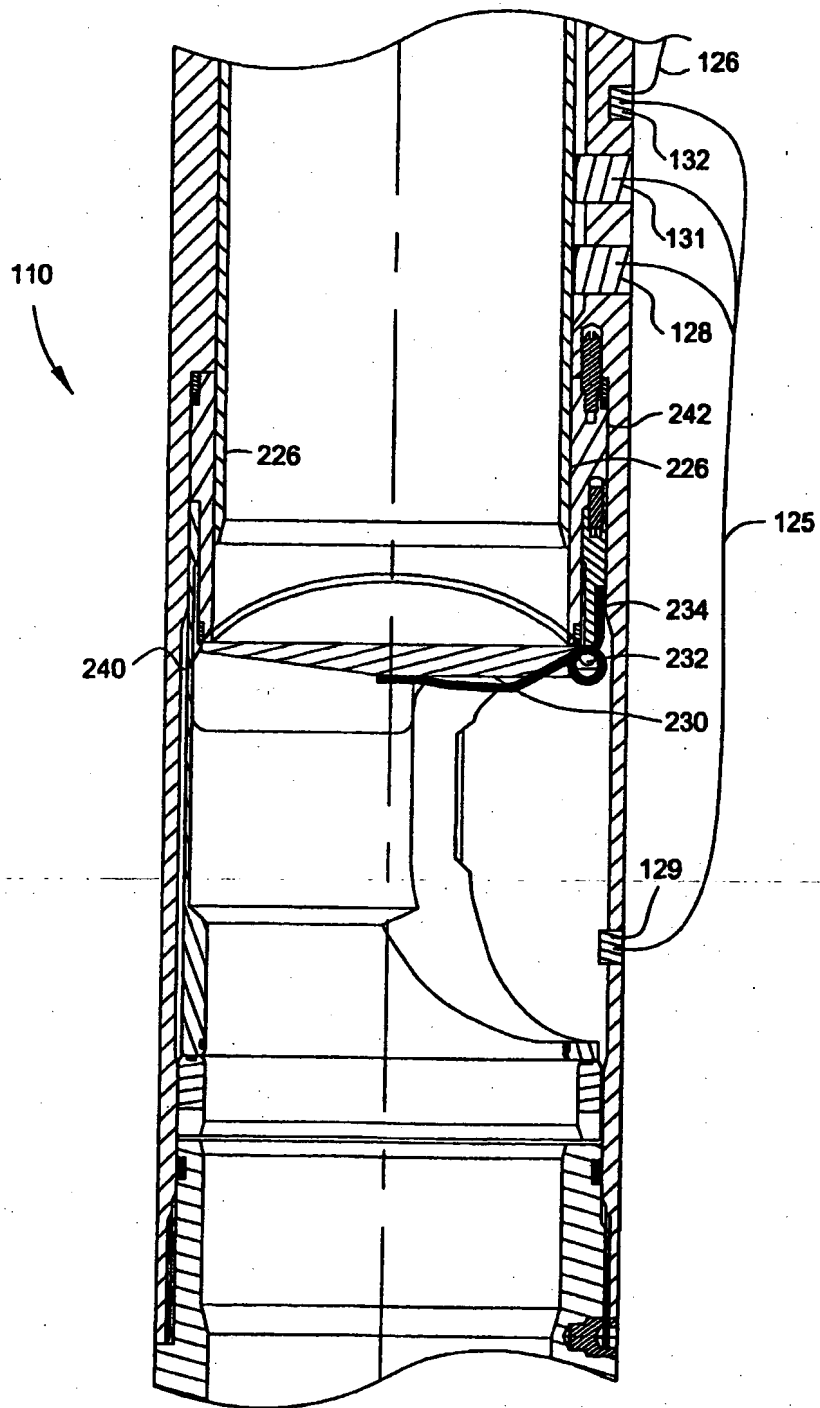


FIG. 3

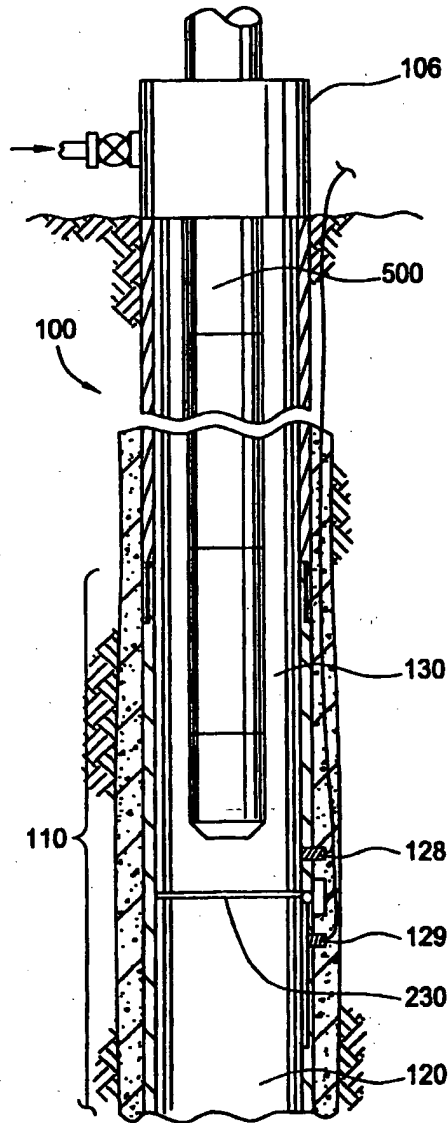


FIG. 5

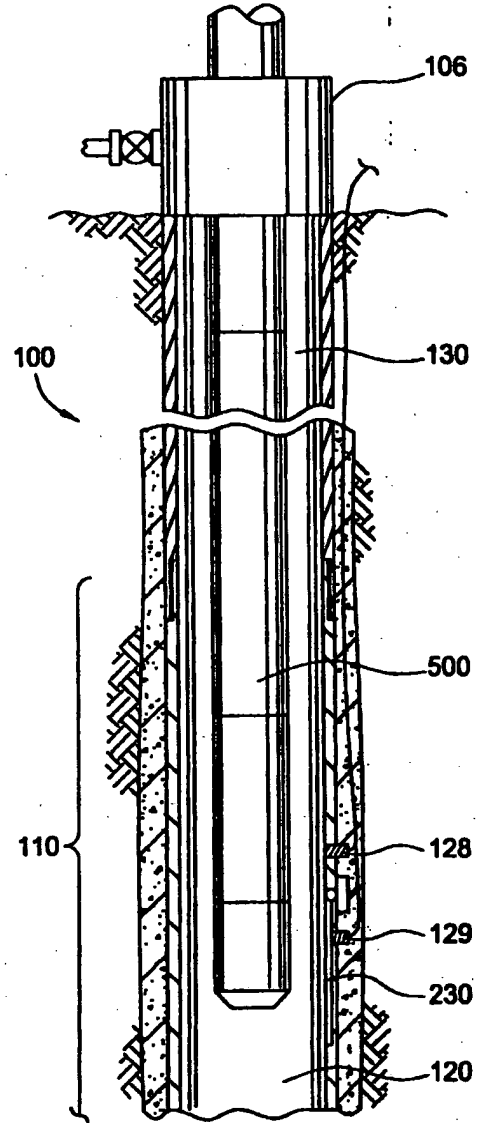


FIG. 6

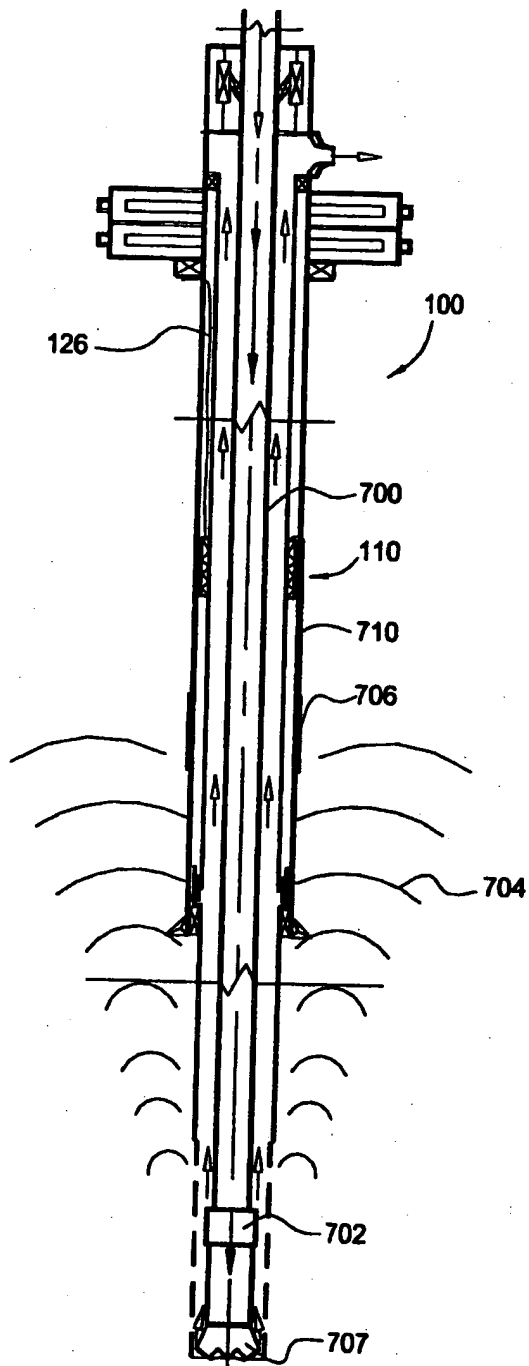


FIG. 7

## **INSTRUMENTATION FOR A DOWNHOLE DEPLOYMENT VALVE**

The present invention generally relates to methods and apparatus for use in oil and gas wellbores. More particularly, the invention relates to methods and apparatus for controlling the use of valves and other automated downhole tools through the use of instrumentation that can additionally be used as a relay to the surface. More particularly still, the invention relates to the use of deployment valves in wellbores in order to temporarily isolate an upper portion of the wellbore from a lower portion thereof.

Oil and gas wells typically begin by drilling a borehole in the earth to some predetermined depth adjacent a hydrocarbon-bearing formation. After the borehole is drilled to a certain depth, steel tubing or casing is typically inserted in the borehole to form a wellbore and an annular area between the tubing and the earth is filled with cement. The tubing strengthens the borehole and the cement helps to isolate areas of the wellbore during hydrocarbon production.

Historically, wells are drilled in an "overbalanced" condition wherein the wellbore is filled with fluid or mud in order to prevent the inflow of hydrocarbons until the well is completed. The overbalanced condition prevents blow outs and keeps the well controlled. While drilling with weighted fluid provides a safe way to operate, there are disadvantages, like the expense of the mud and the damage to formations if the column of mud becomes so heavy that the mud enters the formations adjacent the wellbore. In order to avoid these problems and to encourage the inflow of hydrocarbons into the wellbore, underbalanced or near underbalanced drilling has become popular in certain instances. Underbalanced drilling involves the formation of a wellbore in a state wherein any wellbore fluid provides a pressure lower than the natural pressure of formation fluids. In these instances, the fluid is typically a gas, like nitrogen and its purpose is limited to carrying out drilling chips produced by a rotating drill bit. Since underbalanced well conditions can cause a blow out, they

must be drilled through some type of pressure device like a rotating drilling head at the surface of the well to permit a tubular drill string to be rotated and lowered therethrough while retaining a pressure seal around the drill string. Even in overbalanced wells there is a need to prevent blow outs. In most every instance, wells are drilled through blow out preventers in case of a pressure surge.

As the formation and completion of an underbalanced or near underbalanced well continues, it is often necessary to insert a string of tools into the wellbore that cannot be inserted through a rotating drilling head or blow out preventer due to their shape and relatively large outer diameter. In these instances, a lubricator that consists of a tubular housing tall enough to hold the string of tools is installed in a vertical orientation at the top of a wellhead to provide a pressurizable temporary housing that avoids downhole pressures. By manipulating valves at the upper and lower end of the lubricator, the string of tools can be lowered into a live well while keeping the pressure within the well localized. Even a well in an overbalanced condition can benefit from the use of a lubricator when the string of tools will not fit through a blow out preventer. The use of lubricators is well known in the art and the forgoing method is more fully explained in U.S. patent application number 09/536,937, filed 27 March 2000, and that published application is incorporated by reference herein in its entirety.

While lubricators are effective in controlling pressure, some strings of tools are too long for use with a lubricator. For example, the vertical distance from a rig floor to the rig draw works is typically about ninety feet or is limited to that length of tubular string that is typically inserted into the well. If a string of tools is longer than ninety feet, there is not room between the rig floor and the draw works to accommodate a lubricator. In these instances, a down hole deployment valve or DDV can be used to create a pressurized housing for the string of tools. Downhole deployment valves are well known in the art and one such valve is described in U.S. patent number 6,209,663, which is incorporated by reference herein in its entirety. Basically, a DDV is run into a well as part of a string of casing. The valve is initially in an open position with a flapper member in a position whereby the full bore of the casing is open to the flow of fluid and the passage of tubular strings and tools into and out of the wellbore. In the valve taught in the '663 patent, the valve includes an



axially moveable sleeve that interferes with and retains the flapper in the open position. Additionally, a series of slots and pins permits the valve to be openable or closable with pressure but to then remain in that position without pressure continuously applied thereto. A control line runs from the DDV to the surface of the well and is typically hydraulically controlled. With the application of fluid pressure through the control line, the DDV can be made to close so that its flapper seats in a circular seat formed in the bore of the casing and blocks the flow of fluid through the casing. In this manner, a portion of the casing above the DDV is isolated from a lower portion of the casing below the DDV.

The DDV is used to install a string of tools in a wellbore as follows: When an operator wants to install the tool string, the DDV is closed via the control line by using hydraulic pressure to close the mechanical valve. Thereafter, with an upper portion of the wellbore isolated, a pressure in the upper portion is bled off to bring the pressure in the upper portion to a level approximately equal to one atmosphere. With the upper portion depressurized, the wellhead can be opened and the string of tools run into the upper portion from a surface of the well, typically on a string of tubulars. A rotating drilling head or other stripper like device is then sealed around the tubular string or movement through a blowout preventer can be re-established. In order to reopen the DDV, the upper portion of the wellbore must be repressurized in order to permit the downwardly opening flapper member to operate against the pressure therebelow. After the upper portion is pressurized to a predetermined level, the flapper can be opened and locked in place. Now the tool string is located in the pressurized wellbore.

Presently there is no instrumentation to know a pressure differential across the flapper when it is in the closed position. This information is vital for opening the flapper without applying excessive force. A rough estimate of pressure differential is obtained by calculating fluid pressure below the flapper from wellhead pressure and hydrostatic head of fluid above the flapper. Similarly when the hydraulic pressure is applied to the mandrel to move it one way or the other, there is no way to know the position of the mandrel at any time during that operation. Only when the mandrel reaches dead stop, its position is determined by rough measurement of the fluid emanating from the return line. This also indicates that the

flapper is either fully opened or fully closed. The invention described here is intended to take out the uncertainty associated with the above measurements.

In addition to problems associated with the operation of DDVs, many prior art downhole measurement systems lack reliable data communication to and from control units located on a surface. For example, conventional measurement while drilling (MWD) tools utilize mud pulse, which works fine with incompressible drilling fluids such as a water-based or an oil-based mud, but they do not work when gasified fluids or gases are used in underbalanced drilling. An alternative to this is electromagnetic (EM) telemetry where communication between the MWD tool and the surface monitoring device is established via electromagnetic waves traveling through the formations surrounding the well. However, EM telemetry suffers from signal attenuation as it travels through layers of different types of formations. Any formation that produces more than minimal loss serves as an EM barrier. In particular salt domes tend to completely moderate the signal. Some of the techniques employed to alleviate this problem include running an electric wire inside the drill string from the EM tool up to a predetermined depth from where the signal can come to the surface via EM waves and placing multiple receivers and transmitters in the drill string to provide boost to the signal at frequent intervals. However, both of these techniques have their own problems and complexities. Currently, there is no available means to cost efficiently relay signals from a point within the well to the surface through a traditional control line.

Expandable Sand Screens (ESS) consist of a slotted steel tube, around which overlapping layers of filter membrane are attached. The membranes are protected with a pre-slotted steel shroud forming the outer wall. When deployed in the well, ESS looks like a three-layered pipe. Once it is situated in the well, it is expanded with a special tool to come in contact with the wellbore wall. The expander tool includes a body having at least two radially extending members, each of which has a roller that when coming into contact with an inner wall of the ESS, can expand the wall past its elastic limit. The expander tool operates with pressurized fluid delivered in a string of tubulars and is more completely disclosed in US Patent No. 6,425,444 and that patent is incorporated in its entirety herein by reference. In this manner ESS supports the wall against collapsing into the well,

provides a large wellbore size for greater productivity, and allows free flow of hydrocarbons into the well while filtering out sand. The expansion tool contains rollers supported on pressure-actuated pistons. Fluid pressure in the tool determines how far the ESS is expanded. While too much expansion is bad for both the ESS and the well, too little expansion does not provide support to the wellbore wall. Therefore, monitoring and controlling fluid pressure in the expansion tool is very important. Presently fluid pressure is measured with a memory gage, which of course provides information after the job has been completed. A real time measurement is desirable so that fluid pressure can be adjusted during the operation of the tool if necessary.

There is a need therefore, for a downhole system of instrumentation and monitoring that can facilitate the operation of downhole tools. There is a further need for a system of instrumentation that can facilitate the operation of downhole deployment valves. There is yet a further need for downhole instrumentation apparatus and methods that include sensors to measure downhole conditions like pressure, temperature, and proximity in order to facilitate the efficient operation of the downhole tools. Finally, there exists a need for downhole instrumentation and circuitry to improve communication with existing expansion tools used with expandable sand screens and downhole measurement devices such as MWD and pressure while drilling (PWD) tools.

The present invention generally relates to methods and apparatus for instrumentation associated with a downhole deployment valve (DDV). In one aspect, a DDV in a casing string is closed in order to isolate an upper section of a wellbore from a lower section. Thereafter, a pressure differential above and below the closed valve is measured by downhole instrumentation to facilitate the opening of the valve. In another aspect, the instrumentation in the DDV includes different kinds of sensors placed in the DDV housing for measuring all important parameters for safe operation of the DDV, a circuitry for local processing of signal received from the sensors, and a transmitter for transmitting the data to a surface control unit.

In yet another aspect, the design of circuitry, selection of sensors, and data communication is not limited to use with and within downhole deployment valves. All aspects of downhole instrumentation can be varied and tailored for others applications such as improving communication between surface units and measurement while drilling (MWD) tools, pressure while drilling (PWD) tools, and expandable sand screens (ESS).

In the accompanying drawings

Figure 1 is a section view of a wellbore having a casing string therein, the casing string including a downhole deployment valve (DDV).

Figure 2 is an enlarged view showing the DDV in greater detail.

Figure 3 is an enlarged view showing the DDV in a closed position.

Figure 4 is a section view of the wellbore showing the DDV in a closed position.

Figure 5 is a section view of the wellbore showing a string of tools inserted into an upper portion of the wellbore with the DDV in the closed position.

Figure 6 is a section view of the wellbore with the string of tools inserted and the DDV opened.

Figure 7 is a section view of a wellbore showing the DDV of the present invention in use with a telemetry tool.

Figure 1 is a section view of a wellbore 100 with a casing string 102 disposed therein and held in pace by cement 104. The casing string 102 extends from a surface of the wellbore 100 where a wellhead 106 would typically be located along with some type of valve assembly 108 which controls the flow of fluid from the

wellbore 100 and is schematically shown. Disposed within the casing string 102 is a downhole deployment valve (DDV) 110 that includes a housing 112, a flapper 230 having a hinge 232 at one end, and a valve seat 242 in an inner diameter of the housing 112 adjacent the flapper 230. As stated herein, the DDV 110 is an integral part of the casing string 102 and is run into the wellbore 100 along with the casing string 102 prior to cementing. The housing 112 protects the components of the DDV 110 from damage during run in and cementing. Arrangement of the flapper 230 allows it to close in an upward fashion wherein pressure in a lower portion 120 of the wellbore will act to keep the flapper 230 in a closed position. The DDV 110 also includes a surface monitoring and control unit (SMCU) (not shown as will be described herein) to permit the flapper 230 to be opened and closed remotely from the surface of the well. As schematically illustrated in Figure 1, the attachments connected to the SMCU (not shown) include some mechanical-type actuator 124 and a control line 126 that can carry hydraulic fluid and/or electrical currents. Clamps (not shown) can hold the control line 126 next to the casing string 102 at regular intervals to protect the control line 126.

Also shown schematically in Figure 1 is an upper sensor 128 placed in an upper portion 130 of the wellbore and a lower sensor 129 placed in the lower portion 120 of the wellbore. The upper sensor 128 and the lower sensor 129 can determine a fluid pressure within an upper portion 130 and a lower portion 120 of the wellbore, respectively. Similar to the upper and lower sensors 128, 129 shown, additional sensors (not shown) can be located in the housing 112 of the DDV 110 to measure any wellbore condition or parameter such as a position of the sleeve 226, the presence or absence of a drill string, and wellbore temperature. The additional sensors can determine a fluid composition such as an oil to water ratio, an oil to gas ratio, or a gas to liquid ratio. Furthermore, the additional sensors can detect and measure a seismic pressure wave from a source located within the wellbore, within an adjacent wellbore, or at the surface. Therefore, the additional sensors can provide real time seismic information.

Figure 2 is an enlarged view of a portion of the DDV 110 showing the flapper 230 and a sleeve 226 that keeps it in an open position. In the embodiment

shown, the flapper 230 is initially held in an open position by the sleeve 226 that extends downward to cover the flapper 230 and to ensure a substantially unobstructed bore through the DDV 110. A sensor 131 detects an axial position of the sleeve 226 as shown in Figure 2 and sends a signal through the control line 126 to the SMCU (not shown) that the flapper 230 is completely open. All sensors such as the sensors 128, 129, 131 shown in Figure 2 connect by a cable 125 to circuit boards 133 located downhole in the housing 112 of the DDV 110. Power supply to the circuit boards 133 and data transfer from the circuit boards 133 to the SMCU (not shown) is achieved via an electric conductor in the control line 126. Circuit boards 133 have free channels for adding new sensors depending on the need.

Figure 3 is a section view showing the DDV 110 in a closed position. A flapper engaging end 240 of a valve seat 242 in the housing 112 receives the flapper 230 as it closes. Once the sleeve 226 axially moves out of the way of the flapper 230 and the flapper engaging end 240 of the valve seat 242, a biasing member 234 biases the flapper 230 against the flapper engaging end 240 of the valve seat 242. In the embodiment shown, the biasing member 234 is a spring that moves the flapper 230 along an axis of a hinge 232 to the closed position. Common known methods of axially moving the sleeve 226 include hydraulic pistons (not shown) that are operated by pressure supplied from the control line 126 and interactions with the drill string based on rotational or axially movements of the drill string. The sensor 131 detects the axial position of the sleeve 226 as it is being moved axially within the DDV 110 and sends signals through the control line 126 to the SMCU (not shown). Therefore, the SMCU reports on a display a percentage representing a partially opened or closed position of the flapper 230 based upon the position of the sleeve 226.

Figure 4 is a section view showing the wellbore 100 with the DDV 110 in the closed position. In this position the upper portion 130 of the wellbore 100 is isolated from the lower portion 120 and any pressure remaining in the upper portion 130 can be bled out through the valve assembly 108 at the surface of the well as shown by arrows. With the upper portion 130 of the wellbore free of pressure the

wellhead 106 can be opened for safely performing operations such as inserting or removing a string of tools.

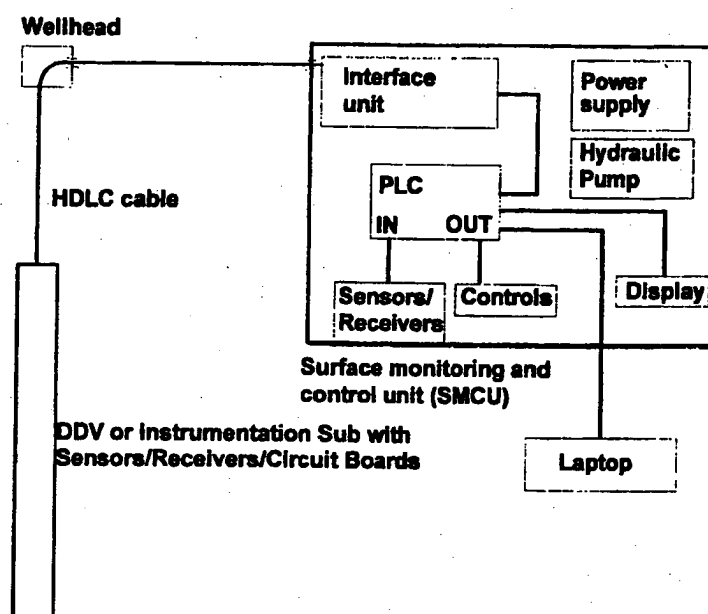
**Figure 5** is a section view showing the wellbore 100 with the wellhead 106 opened and a string of tools 500 having been instated into the upper portion 130 of the wellbore. The string of tools 500 can include apparatus such as bits, mud motors, measurement while drilling devices, rotary steering devices, perforating systems, screens, and/or slotted liner systems. These are only some examples of tools that can be disposed on a string and instated into a well using the method and apparatus of the present invention. Because the height of the upper portion 130 is greater than the length of the string of tools 500, the string of tools 500 can be completely contained in the upper portion 130 while the upper portion 130 is isolated from the lower portion 120 by the DDV 110 in the closed position. Finally, **Figure 6** is an additional view of the wellbore 100 showing the DDV 110 in the open position and the string of tools 500 extending from the upper portion 130 to the lower portion 120 of the wellbore. In the illustration shown, a device (not shown) such as a stripper or rotating head at the wellhead 106 maintains pressure around the tool string 500 as it enters the wellbore 100.

Prior to opening the DDV 110, fluid pressures in the upper portion 130 and the lower portion 120 of the wellbore 100 at the flapper 230 in the DDV 110 must be equalized or nearly equalized to effectively and safely open the flapper 230. Since the upper portion 130 is opened at the surface in order to insert the tool string 500, it will be at or near atmospheric pressure while the lower portion 120 will be at well pressure. Using means well known in the art, air or fluid in the top portion 130 is pressurized mechanically to a level at or near the level of the lower portion 120. Based on data obtained from sensors 128 and 129 and the SMCU (not shown), the pressure conditions and differentials in the upper portion 130 and lower portion 120 of the wellbore 100 can be accurately equalized prior to opening the DDV 110.

While the instrumentation such as sensors, receivers, and circuits is shown as an integral part of the housing 112 of the DDV 110 (See **Figure 2**) in the examples, it will be understood that the instrumentation could be located in a separate "instrumentation sub" located in the casing string. The instrumentation sub

can be hard wired to a SMCU in a manner similar to running a hydraulic dual line control (HDLC) cable from the instrumentation of the DDV 110 (See Diagram 1 below). Therefore, the instrumentation sub utilizes sensors, receivers, and circuits as described herein without utilizing the other components of the DDV 110 such as a flapper and a valve seat.

**Diagram 1** is a schematic diagram of a control system and its relationship to a well having a DDV or an instrumentation sub that is wired with sensors as disclosed herein:



**Diagram 1**

The diagram shows the wellbore having the DDV disposed therein with the electronics necessary to operate the sensors discussed above. (see **Figure 1**) A conductor embedded in a control line which is shown in Diagram 1 as a hydraulic dual line control (HDLC) cable provides communication between downhole sensors and/or receivers and a surface monitoring and control unit (SMCU). The HDLC cable extends from the DDV outside of the casing string containing the DDV to an interface unit of the SMCU. The SMCU can include a hydraulic pump and a series of valves utilized in operating the DDV by fluid communication through the HDLC and in establishing a pressure above the DDV substantially equivalent to the pressure below the DDV. In addition, the SMCU can include a programmable logic



controller (PLC) based system for monitoring and controlling each valve and other parameters, circuitry for interfacing with downhole electronics, an onboard display, and standard RS-232 interfaces (not shown) for connecting external devices. In this arrangement, the SMCU outputs information obtained by the sensors and/or receivers in the wellbore to the display. Using the arrangement illustrated, the pressure differential between the upper portion and the lower portion of the wellbore can be monitored and adjusted to an optimum level for opening the valve. In addition to pressure information near the DDV, the system can also include proximity sensors that describe the position of the sleeve in the valve that is responsible for retaining the valve in the open position. By ensuring that the sleeve is entirely in the open or the closed position, the valve can be operated more effectively. A separate computing device such as a laptop can optionally be connected to the SMCU.

**Figure 7** is a section view of a wellbore **100** with a string of tools **700** that includes a telemetry tool **702** inserted in the wellbore **100**. The telemetry tool **702** transmits the readings of instruments to a remote location by means of radio waves or other means. In the embodiment shown in **Figure 7**, the telemetry tool **702** uses electromagnetic (EM) waves **704** to transmit downhole information to a remote location, in this case a receiver **706** located in or near a housing of a DDV **110** instead of at a surface of the wellbore. Alternatively, the DDV **110** can be an instrumentation sub that comprises sensors, receivers, and circuits, but does not include the other components of the DDV **110** such as a valve. The EM wave **704** can be any form of electromagnetic radiation such as radio waves, gamma rays, or x-rays. The telemetry tool **702** disposed in the tubular string **700** near the bit **707** transmits data related to the location and face angle of the bit **707**, hole inclination, downhole pressure, and other variables. The receiver **706** converts the EM waves **704** that it receives from the telemetry tool **702** to an electric signal, which is fed into a circuit in the DDV **110** via a short cable **710**. The signal travels to the SMCU via a conductor in a control line **126**. Similarly, an electric signal from the SMCU can be sent to the DDV **110** that can then send an EM signal to the telemetry tool **702** in order to provide two way communication. By using the telemetry tool **702** in connection with the DDV **110** and its preexisting control line **126** that connects it to

the SMCU (not shown) at the surface, the reliability and performance of the telemetry tool 702 is increased since the EM waves 704 need not be transmitted through formations as far. Therefore, embodiments of this invention provide communication with downhole devices such as telemetry tool 702 that are located below formations containing an EM barrier. Examples of downhole tools used with the telemetry tool 702 include a measurement while drilling (MWD) tool or a pressure while drilling (PWD) tool.

Still another use of the apparatus and methods of the present invention relate to the use of an expandable sand screen or ESS and real time measurement of pressure required for expanding the ESS. Using the apparatus and methods of the current invention with sensors incorporated in an expansion tool and data transmitted to a SMCU (See Diagram 1) via a control line connected to a DDV or instrumentation sub having circuit boards, sensors, and receivers within, pressure in and around the expansion tool can be monitored and adjusted from a surface of a wellbore. In operation, the DDV or instrumentation sub receives a signal similar to the signal described in Figure 7 from the sensors incorporated in the expansion tool, processes the signal with the circuit boards, and sends data relating to pressure in and around the expansion tool to the surface through the control line. Based on the data received at the surface, an operator can adjust a pressure applied to the ESS by changing a fluid pressure supplied to the expansion tool.

CLAIMS

1. A downhole deployment valve, comprising:  
a housing having a fluid flow path therethrough;  
5 a valve member operatively connected to the housing for selectively obstructing the flow path; and  
a sensor operatively connected to the deployment valve for sensing a wellbore parameter.
- 10 2. The apparatus of claim 1, wherein the wellbore parameter is an operating parameter of the deployment valve.
3. The apparatus of claim 1, wherein the wellbore parameter is selected from a group of parameters consisting  
15 of: a pressure, a temperature, and a fluid composition.
4. The apparatus of claim 1, wherein the wellbore parameter is a seismic pressure wave.
- 20 5. The apparatus of any preceding claim, further comprising a control member for controlling an operating parameter of the deployment valve.
6. The apparatus of claim 5, wherein the operating  
25 parameter is selected from a group of operations consisting of: opening the valve member, closing the valve member, equalising a pressure, relaying the wellbore parameter.
7. The apparatus of claim 1, wherein the wellbore  
30 parameter comprises a signal from a tool in a wellbore.

8. The apparatus of claim 7, wherein the signal represents an operating parameter of the tool.

9. The apparatus of claim 7 or claim 8, wherein the signal  
5 is a pressure wave.

10. The apparatus of any of claims 7 to 9, wherein the signal is a seismic pressure wave.

10 11. An apparatus for transferring information between a tool positioned at a first position within a wellbore and a second position, comprising:

a downhole instrumentation sub;

at least one receiver operatively connected to the  
15 downhole instrumentation sub for receiving a first signal from the tool; and

a transmitter operatively connected to the downhole instrumentation sub for transmitting a second signal to the second position.

20

12. The apparatus of claim 11, wherein the downhole instrumentation sub comprises a deployment valve.

13. The apparatus of claim 11 or claim 12, wherein the  
25 transmitter is a control line.

14. The apparatus of any of claims 11 to 13, wherein the second position is proximate an intersection of the wellbore and a surface of the earth.

30

15. The apparatus of any of claims 11 to 13, wherein the second position is on a surface of the earth.

16. The apparatus of any of claims 11 to 15, further comprising at least one circuit operatively connected to the downhole instrumentation sub.

5

17. The apparatus of any of claims 11 to 16, further comprising a surface monitoring and control unit that receives the second signal.

10 18. The apparatus of any of claims 11 to 17, wherein the first signal is electromagnetic.

19. The apparatus of any of claims 11 to 18, wherein the tool is a measurement while drilling tool.

15

20. The apparatus of any of claims 11 to 18, wherein the tools is a pressure while drilling tool.

20 21. The apparatus of any of claims 11 to 18, wherein the tool is an expansion tool.

22. A downhole tool for use in a wellbore, comprising:  
a housing defining a bore formed therein;  
a valve disposed within the housing and movable between  
25 an open position and a closed position, wherein the closed position substantially seals a first portion of the bore from a second portion of the bore;  
one or more sensors operatively connected to the  
downhole tool; and

30 a monitoring and control unit that collects information provided by the one or more sensors.

23. The apparatus of claim 22, wherein the first portion of the bore communicates with a surface of the wellbore.

24. The apparatus of claim 22 or 23, further comprising a control line connecting the one or more sensors to the monitoring and control unit.

25. The apparatus of any of claims 22 to 24, wherein the monitoring and control unit controls the valve.

26. The apparatus of any of claims 22 to 25, wherein the monitoring and control unit monitors a pressure in the first portion of the bore.

27. The apparatus of any of claims 22 to 26, wherein the monitoring and control unit monitors a pressure in the second portion of the bore.

28. The apparatus of any of claims 22 to 23, wherein the one or more sensors detect whether the valve is in the open position, the closed position, or a position between the open position and the closed position.

29. The apparatus of any of claims 22 to 28, wherein the one or more sensors detect a temperature at the downhole tool.

30. The apparatus of any of claims 22 to 29, wherein the one or more sensors detect a fluid composition at the downhole tool.

31. The apparatus of any of claims 22 to 30, wherein the one or more sensors detect a presence of a drill string within the downhole tool.

5 32. The apparatus of any of claims 22 to 31, further comprising at least one receiver that detects a signal from a transmitting downhole tool.

33. A method for transferring information between a tool  
10 positioned at a first position within a wellbore and a second position, comprising:

disposing a downhole instrumentation sub within the wellbore;

receiving a signal from the tool with at least one  
15 receiver operatively connected to the downhole instrumentation sub; and

transmitting data from the downhole instrumentation sub to the second position.

20 34. The method of claim 33, further comprising relaying the signal to a circuit operatively connected to the at least one receiver.

35. The method of claim 33 or 34, wherein the second  
25 position is a surface of the wellbore.

36. The method of any of claims 33 to 35, wherein the tool is a measurement while drilling tool.

30 37. The method of any of claims 33 to 36, wherein the tool is a pressure while drilling tool.

38. The method of any of claims 33 to 37, wherein the tool is an expansion tool.

39. The method of claim 38, further comprising controlling  
5 an operation of the expansion tool based on the data.

40. The method of claim 38 or 39, further comprising:  
measuring in real time a fluid pressure within the  
expansion tool and a fluid pressure around the expansion  
10 tool during an installation of an expandable sand screen;  
and  
adjusting the fluid pressure within the expansion tool.

41. A method of operating a downhole deployment valve in a  
15 wellbore, comprising:

disposing the downhole deployment valve in the  
wellbore, the downhole deployment valve defining a bore and  
having at least one sensor being monitored by a monitoring  
and control unit;

20 closing a valve in the downhole deployment valve to  
substantially seal a first portion of the bore from a second  
portion of the bore;

measuring a pressure differential between the first  
portion of the bore and the second portion of the bore with  
25 the at least one sensor;

equalising a pressure differential between the first  
portion of the bore and the second portion of the bore; and  
opening the valve in the downhole deployment valve.

30 42. The method of claim 41, wherein the first portion of  
the bore communicates with a surface of the wellbore.



43. The method of claim 41 or 42, wherein disposing the downhole deployment valve in the wellbore comprises connecting the downhole deployment valve to the monitoring and control unit with a control line.
- 5
44. The method of any of claims 41 to 43, further comprising controlling the valve with the monitoring and control unit.
- 10 45. The method of any of claims 41 to 44, further comprising controlling a pressure in the first portion of the bore with the monitoring and control unit.
- 15 46. The method of any of claims 41 to 45, further comprising lowering the pressure in the first portion of the bore to substantially atmospheric pressure.
- 20 47. The method of any of claims 41 to 46, further comprising inserting a string of tools into the wellbore.
- 25 48. The method of any of claims 41 to 47, further comprising determining whether the valve is in an open position, a closed position, or a position between the open position and the closed position with the at least one sensor.
- 30 49. The method of any of claims 41 to 48, further comprising determining a temperature at the downhole deployment valve with the at least one sensor.

50. The method of any of claims 41 to 49, further comprising determining a presence of a drill string within the downhole deployment valve with the at least one sensor.

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51. The method of any of claims 41 to 50, further comprising relaying from the downhole deployment valve to a surface of the wellbore a signal received from a transmitting downhole tool.

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52. A method for communicating with a downhole device below a formation containing an electromagnetic (EM) barrier, comprising:

15

sending an EM signal from a first position below the EM barrier;

receiving the EM signal at a second position below the EM barrier; and

sending a signal between the second position and a third position above the EM barrier.

20

53. The method of claim 52, whereby the signal is transmitted from the third position to the first position via the second position.



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Application No: GB 0325723.5  
Claims searched: 1-10, 22-32 & 41-51

Examiner: Andrew Hughes  
Date of search: 2 February 2004

## Patents Act 1977 : Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	22-31	GB 2335453 A (BAKER HUGHES) pages 37 & 38 and figure 9
X	22-32	GB 2330598 A (BAKER HUGHES) whole document
A	—	US 6209663 B1 (HOSIE)
X, P	1 at least	Weatherford International Ltd., "Downhole deployment valve bulletin" [online], January 2003. Available from <a href="http://www.weatherford.com/weatherford/groups/public/documents/general/wft004406.pdf">http://www.weatherford.com/weatherford/groups/public/documents/general/wft004406.pdf</a>
X, P	1 at least	Weatherford International Ltd., "Nimir field in Oman proves the Downhole Deployment Valve a vital technological key to success" [online], 2003. Available at <a href="http://www.weatherford.com/weatherford/groups/public/documents/general/wft004337.pdf">http://www.weatherford.com/weatherford/groups/public/documents/general/wft004337.pdf</a> An archived version of this page, dated 24 March 2003, is available at <a href="http://web.archive.org/web/20030324141910/http://www.weatherford.com/weatherford/groups/public/documents/general/wft004337.pdf">http://web.archive.org/web/20030324141910/http://www.weatherford.com/weatherford/groups/public/documents/general/wft004337.pdf</a>

### Categories:

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Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.

### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>w</sup>:

E1F

Worldwide search of patent documents classified in the following areas of the IPC<sup>7</sup>:

E21B

The following online and other databases have been used in the preparation of this search report:

Online: EPODOC, WPI & JAPIO

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